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ABSTRACT

This document outlines the procedures to be followed in writing a field or research report. It describes the rationale behind a good report and explains the proper format and use of title, introduction, methods, data, discussion, conclusion, references, and abstract or summary elements. This guide gives aids to writing a good report. Finally, it uses as an example the study of the population density of three periwinkle species at Castine, Maine. This example shows how to define the problem, do a literature search, gather data, and write the report. (BB)

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A GUIDE TO WRITING STUDENT LABORATORY AND FIELD RESEARCH REPORTS

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INTRODUCTION

A report or paper is the final step in a long series of events. These events usually begin when a researcher seeks to answer some perplexing question. As an answer is sought, the researcher reads the reports of others, gathers data, and evaluates and interprets his findings. His findings then become another link in a research chain which allows those who follow to pick up and carry on where he stopped.

The report is a method of communication. It notifies readers of research findings and the way the researcher interpreted them in the light of other research and in the light of accepted theory. As such it includes a rationale for the writing, methods used in gathering the data, the data, a discussion of the findings and conclusions drawn as a result of the findings.

Clearly, research reports are complete documents. They stand on their own and so must be understandable to their readers even though they may not be well versed in research conducted prior to the present project. Also, they must be understandable even though the reader was not present when the data were gathered or had no knowledge of the project prior to reading the report.

Reports or papers which meet these few and simple criteria are assets both to the research community and to the general readership. Those which are vague or in some way incomplete are a waste both of the writer's and the reader's time. You must, therefore, as a writer always strive for excellence.

PURPOSE OF THE GUIDE

Generally science content courses include a weekly laboratory session. During laboratory sessions students conduct experiments chosen to support and to amplify important conceptual material presented in lecture sessions.

A major portion of each experiment is the data-gathering phase. The data which are gathered become points of departure and theoretically lead students to generalizations supporting lecture material. Once integrated, laboratory generalizations and lecture material provide a more well-rounded picture of a subject than is possible if either were studied in isolation. However, recent evidence suggests this schema to be idealistic and that in reality many students, especially when required only to answer a few brief questions over a laboratory exercise, show virtually no gain from the laboratory experience.

Additional problems seem to accumulate when students spend many laboratory sessions treating experiments superficially. A few of those problems are an inability to manipulate data, an inability to interpret data, an inability to use library and other reference sources, an inability to draw conclusions based upon observations, an inability to present data in graphic formats, and paramount of all, an inability to express one's self in writing.

However, many of these deficiencies are greatly reduced and the student's expertise concomitantly increased when writing a formal research report is required following the completion of each laboratory activity.

This guide was specifically written for use in Chemistry, Oceanography, and Physics courses but its principles may be applied

to all laboratory and field investigations.

CONDUCT OF LABORATORY AND FIELD INVESTIGATIONS

Periods of time spent either in the field or in the laboratory are usually devoted to equipment setup and data gathering. Since it is important to be able to review these periods after they are over, field notebooks must be kept.

Field notebooks are as the name suggests - notebooks used in either the field or the laboratory. They are a hand-written collection of notes taken at the moment observations are made, are not rewritten at some later time, and should not include recollections of what one thinks he remembers to have happened at some previous time. They should include all information relevant to an investigation or which might have some bearing upon the investigation's outcome. For example, a section covering a specific investigation might include the date, time of day the observations were made, weather conditions at the time of the observations (temperature, height of the tide, cloud cover, sea conditions), equipment employed, how the equipment was employed, numbers and names of people engaged in the investigation and the actual data which were collected.

The information contained in the field notebook becomes the basis for the majority of the investigator's field or laboratory research report. Therefore, a poorly or inadequately kept field notebook necessarily leads to a poor or inadequate final report.

RESEARCH REPORT FORMAT

Research reports should contain at least the following sections. In addition, each section of each separate report should be preceeded by the respective heading.

TITLE: The title should be comprehensive, and reflect the contents of the report. This is the first item seen by the reader (except when an abstract is included - see below) and that part which tells the reader whether from his or her perspective the report is worth reading.

INTRODUCTION: This section includes the rationale for the investigation (why was the research undertaken, what question or questions were to be answered, or what problem was to be solved), the history of the problem or question (what have other researchers found in this area - is there an accepted theory to be substantiated or disproved) and any hypotheses the investigator formulates concerning the final outcome of the investigation.

Information for much of this section is obtained from other research papers, texts, and other library information. The section should provide a logical link between the problem and the research methodology.

METHODS: Here the writer explains to the reader exactly how his data were gathered. However, it is not necessary for the writer to explain to the readership the internal functioning data-gathering equipments. If a reader desires to know how a galvanometer or some other piece of equipment functions he or she is obligated to consult the literature for such answers.

The information in this section should come directly from the field notebook.

DATA: As was the case with the Methods section, the informa-

tion in this section should come directly from the field notebook.

The data may be presented using graphs, charts, tables, and diagrams, but it must be described in writing. Graphs, tables, charts, and diagrams are used only to provide a visual representation of that which is in writing. For the sake of ease it is generally acceptable to lump all graphs, charts, and diagrams as figures.

When figures and tables are used they should be successively numbered and each should have its own title. Each title should reflect the exact contents of the table or figure and each should be drawn in accordance with the guidance of a style manual. Three such manuals are listed in the Reference section of this guide, and several additional ones are to be found in the Academy Library.

DISCUSSION: This section contains a discussion of your data with respect to any hypotheses you may have formulated. You may find it advantageous here to compare your findings to those of others. In any event, be as brief and straightforward as possible. This is not the place to describe to the reader everything that has transpired thus far in the investigation.

You may use tables and figures in this section. If used, they should present the results of data manipulations.

CONCLUSIONS: In this section the student should draw conclusions based upon his or her findings. The writer may wish to conclude based upon interpretations of the study's data that the findings support those of other specific studies or agree with or disagree with accepted theory. In cases of investigations designed to exemplify a theory, where the findings did not exactly support

the theory the writer may wish to draw conclusions related to experimental error.

Although beginning laboratory and field student investigators tend to conclude that experiments worked nicely or were a success, this practice should be avoided at all costs. The reader is the one who decides upon the success or failure of the investigation. Further, this determination normally depends upon the presentation.

REFERENCES: This section should include all references cited in context. The citations should be listed alphabetically by the author's last name. The remainder of the citation should be consistent with guidance provided by a style manual.

SUMMARY OR ABSTRACT: Generally speaking, summaries preceed references sections while abstracts preceed titles. Whatever the case, this section is but a few brief sentences describing the investigation's methods, findings, and conclusions.

AIDS TO WRITING A GOOD REPORT

Tense and person. All reports should be written in standard English. They should be written in the third person and since the writing concerns an investigation which has already been completed, the past tense should be used.

Abbreviations. While the use of some abbreviations such as those for millimeters, cubic centimeters, kilometers, and the like are generally acceptable in research report writing, others are not. As a guide, all words in the text of a report should be spelled out in full.

Proof reading. Perhaps the most overlooked area by beginning

student research report writers is that of proof reading. Proof reading allows the location of misspellings, typographical errors, and poor sentence structure.

Colleague reading. Colleague reading is perhaps the final step prior to preparation of a final draft. In this step, your report is given to a colleague who is generally unfamiliar with your investigation. If that person can read and understand what you have done then the report will probably be clear to the general readership. If your colleague has difficulty with the report, it should be changed accordingly.

As a further guide to your colleague remember one mark of a good written report is that it will allow the study to be replicated without additional information.

SAMPLE PROBLEM

SITUATION. In the vicinity of Castine, Maine three species of periwinkles are observed. Also, there appears to be a preponderence of the common periwinkle Littorina littorea and fewer numbers respectively of the smooth periwinkle Littorina obtusata and the rough periwinkle Littorina saxatilis. However, at two sites there appear to be fewer of the former species and greater numbers of the latter two species.

As a researcher, you seek to resolve the issue by answering two questions. Those questions are: (1) Which species of periwinkle has the greatest population density in the Castine vicinity?; (2) How do the findings related to the first question compare with population density in the periwinkles' geographical range?

THE LITERATURE. The first step is to consult the literature. In this step the researcher hopes to locate related findings of other researchers. Two such references are quickly located. They are: (1) Smith, A. B. and Jones, C. D. Population densities of three periwinkle species in the littoral zone at Penobscot, Maine. The Blue Hill Biological Review, 1896, 25 (8), 38-40. The authors of this article concluded that at Penobscot, Maine the most prolific periwinkle species in the midlittoral zone was the common periwinkle; (2) Schultz and Schlitz, Biology of the Maine Coast. New York: MacMillan, 1977. The authors of the text state that the most prolific periwinkle along the Maine Coast in the lower littoral zone is the common periwinkle.

YOUR STUDY. Since the Castine Coastline is short it was decided to make a transect every 200 meters with the first situated at Dices Head. In all, 10 transects were taken at low tide. Four equally spaced ¼m square areas were sampled along each transect. The first of these 4 areas was situated adjacent to the mean high-water mark and the fourth adjacent to the mean low-water mark. This meant that the total numbers of periwinkles were counted at four different levels in the intertidal zone for each transect.

YOUR DATA. C = Common Periwinkle, R = Rough Periwinkle, S = Smooth Periwinkle.

Station	1/2 M^2 AREAS											
	1			2			3			4		
	C	S	R	C	S	R	C	S	R	C	S	R
1	20	0	12	25	2	4	25	4	0	30	8	0
2	19	0	7	20	1	6	24	3	0	21	9	0
3	15	0	16	22	3	4	20	6	0	19	10	0
4	11	0	10	21	2	7	22	8	0	28	11	0
5	12	0	17	18	0	2	19	7	0	15	7	0
6	10	0	10	20	1	1	23	9	0	19	8	0
7	14	0	3	22	2	6	24	5	0	24	12	0
8	29	0	8	24	1	7	27	8	0	26	14	0
9	10	0	16	20	3	5	30	4	0	28	12	0
10	24	0	5	21	3	3	15	7	0	19	13	0

YOUR REPORT. Population Densities of Three Periwinkle Species at Castine, Maine.

INTRODUCTION:

That three species of periwinkles exist in Eastern Maine's intertidal zone has been known for the past eighty years (Smith and Jones, 1896). However, which species is most prolific throughout the zone remains in doubt (Smith and Jones, 1896; Schultz and Schlitz, 1977). Smith and Jones (1896) found the common periwinkle to be the largest group in the middle littoral zone at Penobscot, Maine while Schultz and Schlitz (1977) suggested this species to be the most prolific in the low portions of the intertidal zone

throughout the Maine coast.

Recent observations in the Castine, Maine area suggested the common periwinkle to have a greater population density than either the smooth or the rough periwinkle at all levels within the intertidal zone. Therefore, it was decided, using controlled conditions, to ascertain the validity of these observations. Further, the common periwinkle was hypothesized to be the most prolific periwinkle species at all levels of the intertidal zone at Castine, Maine.

METHODS:

The data were collected from 10 transects spaced 200 meters apart. The transects were numbered successively from west to east, extended from the mean high-water line to the mean low-water line (a distance of 4 meters at Castine) and transect number one was located at Dices Head.

Periwinkles were counted at four equally spaced 1/2 m^2 areas within each transect and the first 1/2 m^2 area was located adjacent to the mean high-water mark. In this manner, a total of 40 individual 1/2 m^2 areas were sampled during the conduct of the study.

DATA:

The data are presented in the tabular form in Table 1. In the Table, "C" represents the common periwinkle, "S" - the smooth periwinkle, and "R" - the rough periwinkle.

The common periwinkle exhibited the greatest population density at all levels within the intertidal zone. Smooth periwinkles were not found at the highest level within the zone but increased in numbers as the depth below the mean high-water mark increased.

Members of the rough periwinkle species were not encountered in the lower portions of the zone. Further, their numbers were found to increase as the depth below the mean high-water mark decreased.

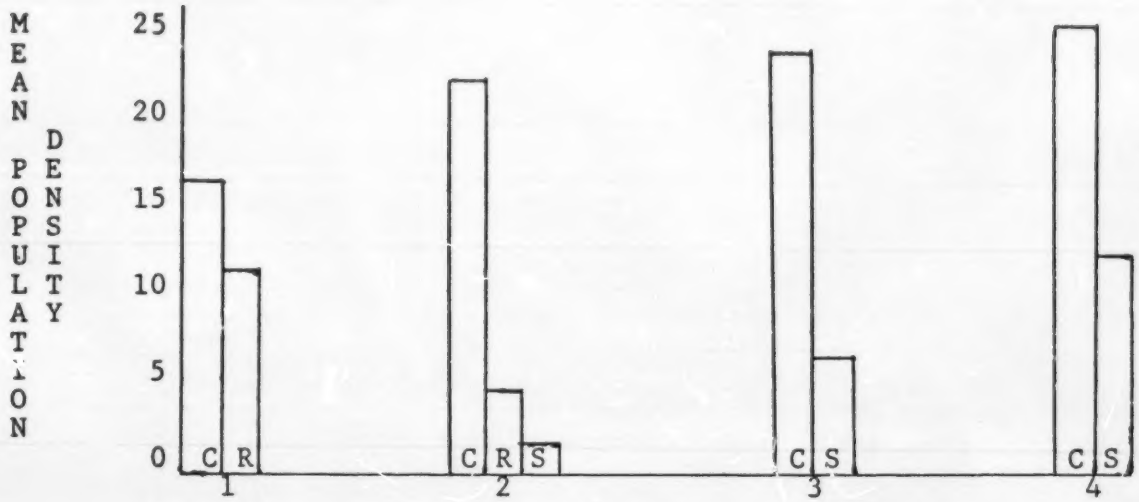
TABLE 1

Numbers of Periwinkles by Species Counted in 10 Transects

1/2 METER ^{2}		1			2			3			4		
		SPECIES											
STATION NO.		C	S	R	C	S	R	C	S	R	C	S	R
WEST TO EAST	1	20	0	12	25	2	4	25	4	0	30	8	0
	2	19	0	7	20	1	6	24	3	0	21	9	0
	3	15	0	16	22	3	4	20	6	0	19	10	0
	4	11	0	10	21	2	7	22	8	0	28	11	0
	5	12	0	17	18	0	2	19	7	0	15	7	0
	6	10	0	10	20	1	1	23	9	0	19	8	0
	7	14	0	3	22	2	6	24	5	0	24	12	0
	8	19	0	8	24	1	7	27	8	0	26	14	0
	9	10	0	16	20	3	5	30	4	0	28	12	0
	10	24	0	5	21	2	3	15	7	0	19	13	0

DISCUSSION:

The original hypothesis was accepted. The common periwinkle was found to be the most prolific periwinkle species at Castine, Maine. The numbers of individuals in the common species per unit area seems fairly constant through the intertidal zone. See Figure 1.



Increasing depth below mean high-water by 1/2 m^2.

FIGURE 1

MEAN POPULATION DENSITIES OF COMMON, ROUGH, AND SMOOTH PERIWINKLES AT FOUR DEPTHS BELOW THE MEAN HIGH-WATER MARK.

The findings suggest the second most abundant species in the higher intertidal zone to be the rough periwinkle and that in the lower portion of the zone to be the smooth periwinkle. These findings also suggest an inability on the part of rough periwinkle to intrude into the lower intertidal zone and the smooth periwinkle to intrude into the higher reaches of the zone.

CONCLUSION:

The findings of this study are consistent with those of Smith and Jones (1896) and Schultz and Schlitz (1977).

The common periwinkle is the most abundant species in the middle and lower intertidal regions at Castine, Maine. In addition, four further conclusions related to periwinkle polulation densities at Castine are: (1) the most abundant species in the high intertidal zone is the common periwinkle; (2) the population of common periwinkles is equally dispersed throughout the intertidal zone;

(3) the second most abundant species in the upper intertidal zone is the rough periwinkle; (4) the second most abundant periwinkle species in the lower intertidal zone is the smooth periwinkle.

Whether or not conclusions three or four are generalizable to a broader geographic area requires additional research.

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